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(54) High speed tyre uniformity testing device.

(57) A high speed tyre uniformity testing device (10) which is constructed to prevent mechanical resonances in the tyre load frame during high frequency testing, thereby permitting undistorted measurements of higher harmonic force variation signals from the tyre. A test tyre (24) is mounted to a rotatable spindle (26) within a housing (28) for selective engagement with a road wheel (20). The housing is supported and manoeuvred by a plurality of vertical (30) and horizontal (32) members, each member including universal joints (34) at its opposite ends to prevent bending moments from being applied to the members. Since only tension and compression forces are applied to the members, a very stiff load frame is provided for the test tyre. One of the members comprises a linear actuator (42) which is spaced substantially away from the longitudinal axis of the housing (28) to provide additional stability to the housing (28) during testing. Load cells (50) are connected to the members for the purpose of measuring the tension or compression variations due to the rolling engagement between the test tyre (24) and road wheel (20).

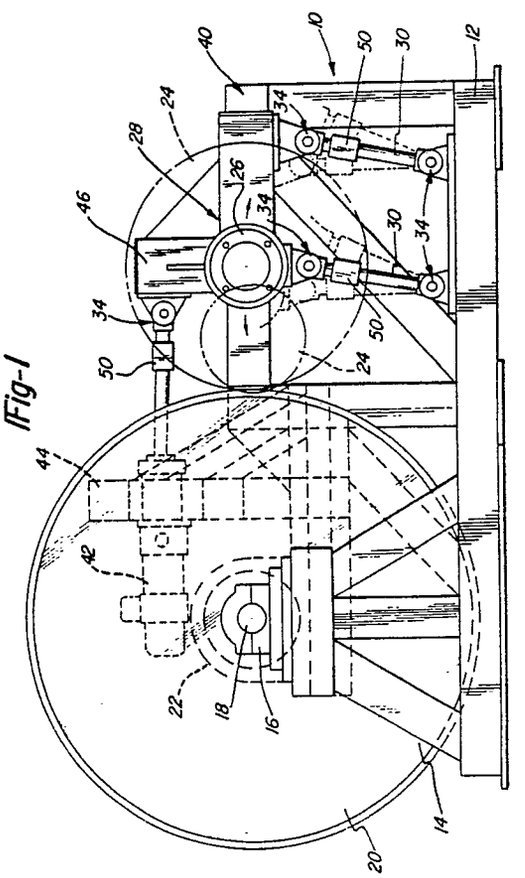

Fig-1

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HIGH SPEED TYRE UNIFORMITY TESTING DEVICE

The present invention relates to a high speed tyre uniformity testing device.

In the prior art, there are a number of tyre testing machines of various kinds such as those shown in U.S. Patent Nos. 3,060,734; 3,206,973; 3,543,576; 3,546,936; 3,604,245 and 3,797,306. These devices typically include large frames that are required for moving the tyre into position against a testing wheel. Such cumbersome mechanisms increase the cost of construction and make installation and servicing difficult. None of these devices provide an efficient, relative lightweight and accurate tyre testing apparatus that can be easily instrumented to provide for an analysis of all of the required loads and movements necessary for tyre compliance testing.

Tyre uniformity measurements are primarily associated with an assessment of the radial, fore/aft, and lateral force variations to be expected at the centre of a tyre rolling at a constant loaded radius. The need for tyre uniformity measurements results from the fact that the tyre may be the cause of vehicle vibrations. Previously, this sensitivity was mostly related to the first harmonic of the tyre's non-uniformity. This first harmonic sensitivity feels very much like tyre unbalance, having a once per tyre revolution vibration rate.

The force variation signals from a tyre can be decomposed into a series of sinusoidal components wherein the component having one cyclic variation per tyre revolution is referred to as the first harmonic, that with two complete cycles per tyre revolution is referred to as the second harmonic, etc. When one of these harmonics excites a resonant mode of vehicle vibration, a noticeable disturbance may be felt inside the vehicle. Since the first harmonic force typically has the largest peak-to-peak amplitude, that harmonic is usually the most noticeable. However, the higher harmonics become noticeable when beating together, i.e., interfering and reinforcing one another. Nevertheless, typical tyre uniformity measurements in the prior art have only included the first harmonic peak-to-peak values for the radial and lateral force variation signals from the tyre since it was believed that a low speed measurement of these quantities provided the necessary correlation to ride comfort ratings.

With the ever-increasing use of radial tyres, which have lower resonant frequencies than bias ply tyres, it has become important to measure higher harmonic excitations because of the disturbances caused by these higher harmonics. A problem exists, however, because prior art devices, which commonly comprise a rotatable wheel mounted on an axle, means for supporting said wheel on a frame and means operatively connected to said axle for driving said wheel, are not able to readily assess the disturbances produced by the higher harmonics. Moreover, the smaller and lighter vehicles being produced today with unibody construction are generally more sensitive to these higher harmonics, thereby producing an even greater need for such measurements.

The present invention seeks to provide a high speed tyre uniformity testing device which will not resonate within the test frequency range of approximately 1-200 Hz that is required for measuring higher tyre harmonics. It is preferred that the device include a very stiff but lightweight load frame so that all resonances therein are above 200 Hz with the load frame being easy to install, relocate and maintain.

In accordance with the present invention there is provided apparatus for testing tyres at high speed comprising a rotatable wheel mounted on an axle, means for supporting said wheel on a frame, and means operatively connected to said axle for driving said wheel, characterised by a tyre mounting means connected to a housing for rotatably mounting a test tyre and a linear actuator connected to said housing by means of a universal joint for moving said housing and test tyre toward and away from said wheel, said housing being connected to said frame by means of first and second tie rod members with said first tie rod member being connected between the frame and the underside of said housing and said second tie rod member being connected between the frame and a side of said housing, the angle formed between the axes of said first and second members being substantially 90 degrees, and said die rod members being connected to said housing and said frame by means of universal joints whereby only tension and compression forces are applied to said members when said test tyre is rotatable engaged against said wheel.

The present invention provides a high speed tyre uniformity testing machine which is constructed such that no mechanical resonances exist within the measurement frequency range of approximately 1-200 Hz, thereby permitting the measurements of both higher harmonic excitation rates and increased fore/aft non-uniformity forces that increase with tyre speed. The device permits the movement of a test tyre against a road wheel in a relationship for accurate testing. Suitable controls may be provided to adequately control and instrument the tyre testing device.

The main support base for the device includes

opposed vertical frames for rotatably supporting an axle of a road wheel. The road wheel is driven by a drive motor which is operatively connected thereto. A test tyre is mounted to a rotatable spindle on a housing for selective engagement with the road wheel. The housing is supported by a plurality of vertical tie rods and horizontal tie rods with each tie rod including universal joints at its opposite ends. The test tyre is drawn against or disengaged from the road wheel by means of a linear actuator which is connected to the housing by yet another universal joint.

The axis of the linear actuator is spaced substantially above the main longitudinal axis of the housing to provide the necessary stability to the housing during testing. Load cells are connected to the tie rods and actuator for the purpose of measuring tension of compression variations along the connecting links to the housing due to the rolling engagement between the test tyre and road wheel. Significantly, the tie rods provide for maximum stiffness when the tyre is rotatably engaged against the road wheel because the universal joint connections prevent the application of bending moments to the tie rods, and therefore, only tension and compression forces are applied. Since such members are strongest in tension or compression, they provide maximum stiffness while requiring the least amount of mass. Thus, the very stiff load frame assures that no mechanical resonances will exist within the intended test frequency range of approximately 1-200 Hz, thereby permitting undistorted measurements of higher harmonics in the test tyre.

The invention is described further hereinafter, by way of example only, with reference to the accompanying drawings, in which:

Fig.1 is a side elevational view of one embodiment of a high speed tyre uniformity testing device in accordance with the present invention;

Fig.2 is a top plan view of the tyre uniformity testing device of Fig. 1;

Fig.3 is an end view of the tyre uniformity testing device of Fig. 1; and

Fig.4 is a partial cross-section illustrating a universal joint which forms part of the tyre uniformity testing device of Fig.1.

A high speed tyre uniformity testing machine 10 is disclosed in Figures 1 to 4. A main support base 12 includes opposed vertical support frames 14 having bushings 16 on their upper ends for rotatably supporting an axle 18 for a road wheel 20. The road wheel 20 is driven by a drive motor 22 which is operatively connected to axle 18.

A test tyre 24 is mounted to a rotatable spindle 26 within housing 28 for selective engagement with road wheel 20. Housing 28 is supported by a plurality of vertical tie rods 30 and horizontal tie rods 32. The tie rods 30 and 32 include universal joints 34 at their opposite ends, each comprising ball bearing members 36 and 38 as is typically shown in Fig. 4. Each of the vertical tie rods 30 is connected by the universal joints 34 between the underside of housing 28 and main support base 12. Each of the horizontal tie rods 32 is connected by the univeral joints 34 between a side of housing 28 and vertical support structure 40 extending upwardly from support base 12.

Test tyre 24 is drawn against or disengaged from road wheel 20 by means of a linear actuator 42 which is mounted to a support structure 44 at its cylinder end. Actuator 42 is connected at its piston end to a vertically protruding portion 46 of housing 28 by another universal joint 34. The axis of linear actuator 42 is spaced substantially above the main longitudinal axis of housing 28, which is generally coincident with the rotational axis of road wheel 20, to provide the necessary stability to housing 28 during its movement toward and away from road wheel 20. Fig. 1 illustrates, in phantom lines, the maximum and minimum diameters for test tyre 20 that can be mounted to housing 28 and drawn against or disengaged from road wheel 20 by actuator 42.

A plurality of load cells 50 are connected along the lengths of tie rods 30 and 32 and the piston end of actuator 42 for the purpose of measuring tension or compression variations along the connecting links, i.e., 30,32 and 42, between frame 12 and housing 28 due to the rolling engagement between test tyre 24 and road wheel 20. Significantly, the tie rods 30 and 32 provide for maximum stiffness when tyre 24 is rotatably engaged against road wheel 20 because of the universal joint connections 34 which prevent bending moments from being applied to the tie rods, and therefore, only tension and compression forces are applied to the tie rods. Since the tie rods are strongest in tension or compression, they provide maximum stiffness against loads applied to housing 28 while requiring the least amount of mass.

Thus, a very stiff load frame is provided for test tyre 24 to prevent mechanical resonances in the frame members for test frequency ranges lower than 200 Hz. This permits testing of tyres at higher speeds which produce higher harmonics of radian, lateral, and fore/aft non-uniformity forces in the tyre.

Claims

1. Apparatus for testing tyres at high speed comprising:
a rotatable wheel mounted on an axle, means for supporting said wheel on a frame, and means operatively connected to said axle for driving said

wheel, characterised by a tyre mounting means connected to a housing (28) for rotatably mounting a test tyre (24) and a linear actuator (42) connected to said housing (28) by means of a universal joint (34) for moving said housing (28) and test tyre (24) toward and away from said wheel (20), said housing (28) being connected to said frame (14,40,12) by means of first (30) and second (32) tie rod members with said first tie rod member being connected between the frame (12) and the underside of said housing (28) and said second tie rod member being connected between the frame (40) and a side of said housing (28), the angle formed between the axes of said first and second members being substantially 90 degrees, and said tie rod members being connected to said housing and said frame by means of universal joints (34) whereby only tension and compression forces are implied to said members when said test tyre (24) is rotatably engaged against said wheel (20).

2. Apparatus as claimed in claim 1, characterised by a plurality of first (30) tie rod members and a plurality of second (32) tie rod members with said first tie rod members forming four bar linkage connections between said frame (12) and the underside of said housing (28) and said second tie rod members forming four bar linkage connections between the frame (40) and the side of said housing (28).

3. Apparatus as claimed in claim 1 or 2, characterised in that each of said tie rod members and said actuator includes load cells (50) positioned for measuring tension or compression variations in response to rolling engagement between the test tyre and wheel.

4. Apparatus as claimed in any of claims 1 to 3, characterised in that the axis of said linear actuator (42) is spaced substantially away from the axis of said housing (28) to provide stability to the housing during its movement toward and away from the wheel.

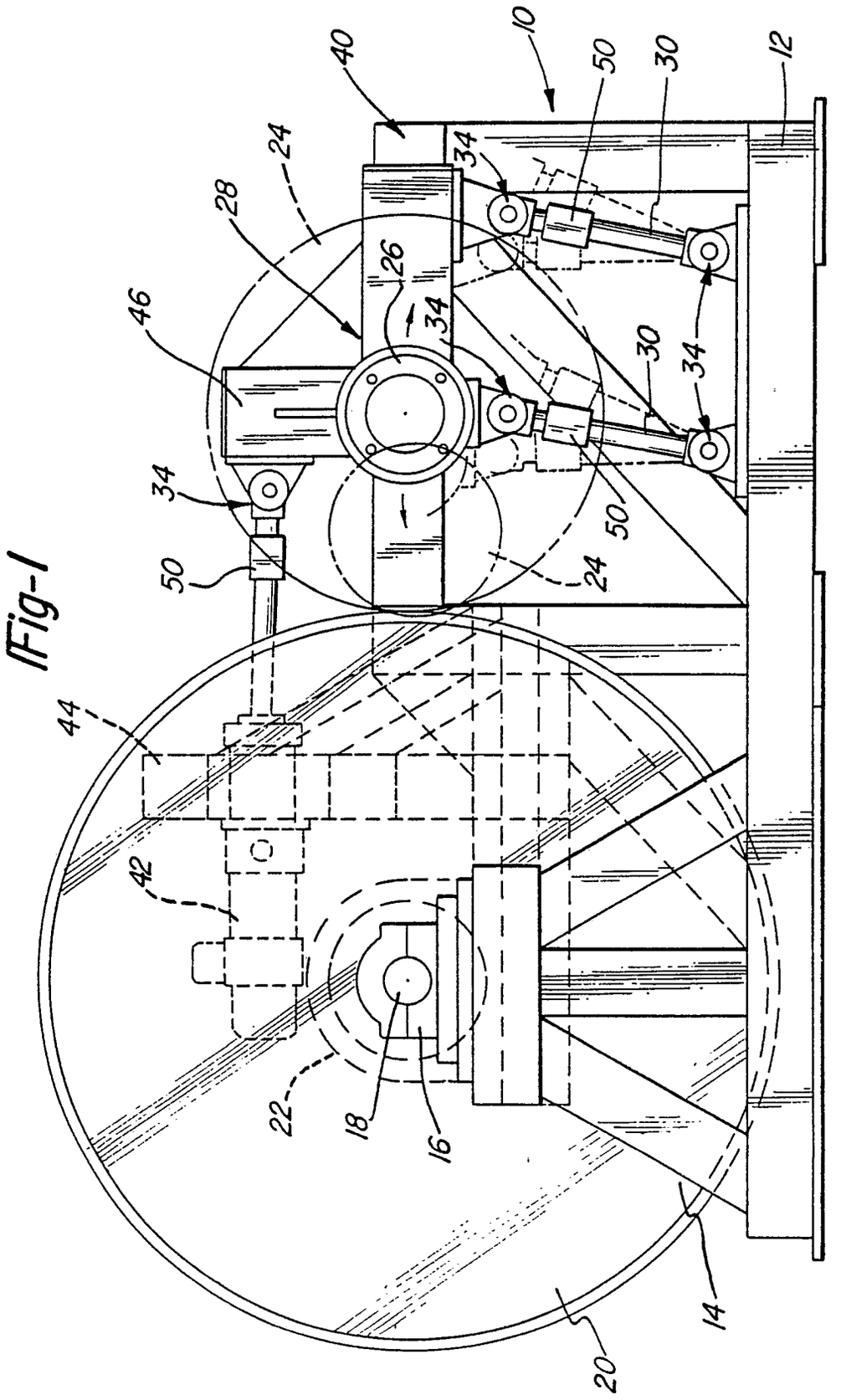

Fig-1

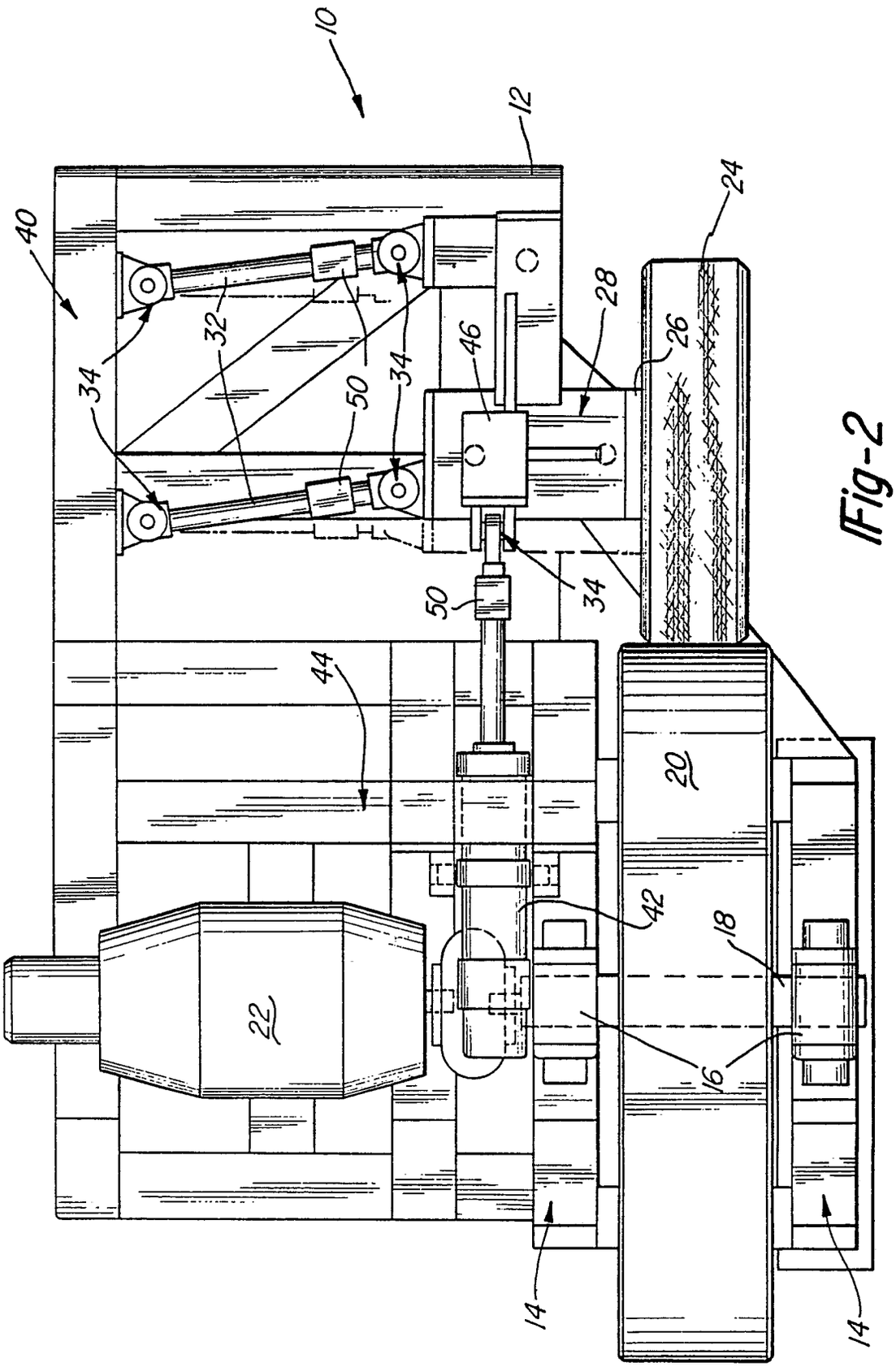

Fig-2

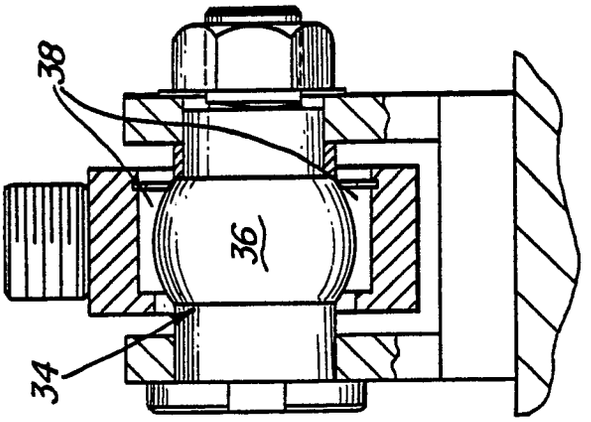

Fig-4

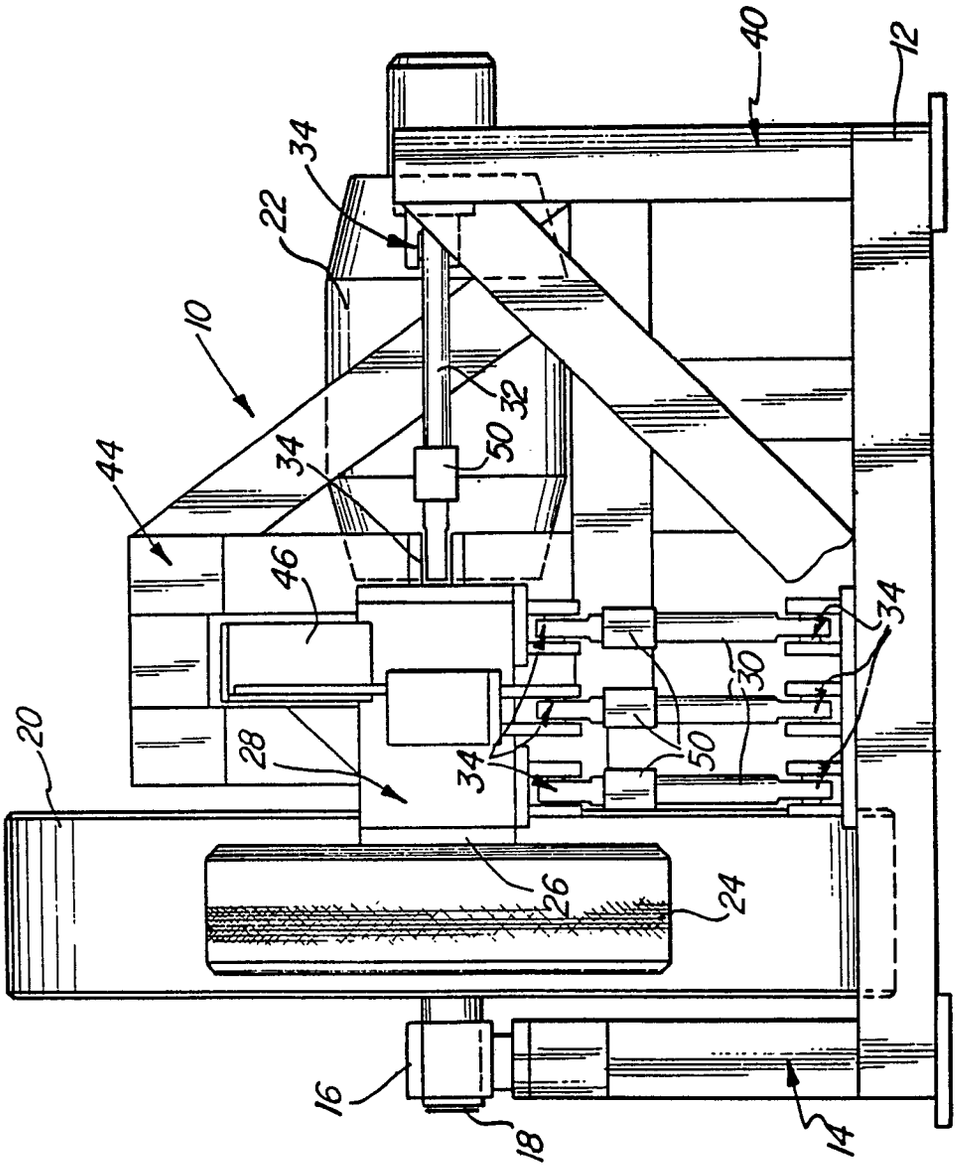

Fig-3

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EUROPEAN SEARCH REPORT

Application Number

EP 87 30 7728

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
X	SOVIET INVENTIONS ILLUSTRATED, week E04, 10th March 1982, Derwent Publications Ltd, London, GB; & SU-A-821 998 (BELO POLY) 20-04-1981 * Whole document *	1-3	G 01 M 17/02
Y	Idem	4	
Y	DE-A-3 040 252 (R. GNADLER) * Whole document *	1-4	
Y	DE-A-2 320 322 (CARL SCHENCK MASCHINENFABRIK GmbH) * Pages 4-6; figures *	1	
Y	US-A-4 499 759 (F.H. HULL) * Whole document *	1	
Y	US-A-2 367 838 (R.W. ALLEN) * Whole document *	1-4	
Y	EP-A-0 063 245 (FRAUNHOFER-GESELLSCHAFT ZUR FÖRDERUNG DER ANGEWANDTEN FORSCHUNG e.V.) * Abstract; figures *	1-4	TECHNICAL FIELDS SEARCHED (Int. Cl.4) G 01 M 17

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	26-04-1988	VAN ASSCHE P.O.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

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